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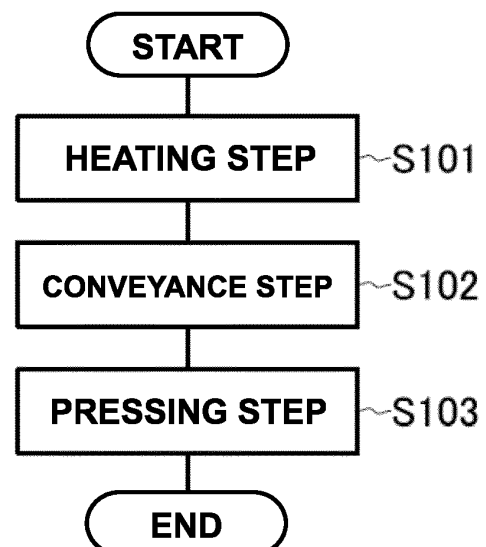
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(54) **PRODUCTION METHOD**

(57) A production method includes a first step of heating an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance, to a temperature for enabling press forming in a state in which precipitation hardening is maintained, a conveyance step (S102) of storing the heated aluminum alloy sheet in a box body of the above-described conveyance apparatus and conveying the aluminum alloy sheet in a state in which heated air is introduced into the box body to suppress temperature drop of the aluminum alloy sheet, and a pressing step of (S103) pressing the aluminum alloy sheet conveyed in the conveyance step (S102).

FIG.1



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Description

Technical Field

[0001] The present invention relates to a production method for pressing an aluminum alloy sheet.

Background Art

[0002] For example, as a material for forming a part (vehicle body part) of a vehicle, for example, a high-strength metal sheet such as a high-tensile steel sheet or an aluminum alloy sheet is used to reduce the weight. A part of this type is formed by pressing a steel sheet or an aluminum alloy sheet. To press a high-strength metal sheet, hot press is used. For example, when hot-pressing a high-tensile steel sheet, the high-tensile steel sheet is heated to 950°C and thus changed to an austenite structure, and in this state, hot press is performed. Simultaneously, when brought into contact with a die, the high-tensile steel sheet is cooled and thus quenched (changed to a hard structure called a martensite structure), thereby forming a high-strength part (patent literature 1).

[0003] In this hot press, generally, the high-tensile steel sheet is heated in a heating furnace, a conveyance step of unloading the heated high-tensile steel sheet from the heating furnace and conveying the unloaded high-tensile steel sheet to a press machine is performed, and then, pressing is performed. In the conveyance step, after the high-tensile steel sheet heated to about 950°C is unloaded from the heating furnace, the unloaded high-tensile steel sheet is conveyed to the press machine. Since the heating temperature is high, temperature drop in the conveyance step poses no problem for the press forming property in the next step.

Related Art Literature

Patent Literature

[0004] Patent Literature 1: Japanese Patent No. 4094473

Summary of Invention

Problem to be Solved by the Invention

[0005] On the other hand, to reduce the weight more than the high-tensile steel sheet, an aluminum alloy sheet is used for a vehicle body part. In the aluminum alloy sheet, if a heat loss caused by radiation or the like during the above-described conveyance is large, normal pressing cannot be executed. Hence, for example, the distance between the heating furnace and the press machine may be shortened to shorten the conveyance distance and suppress the heat loss. However, there is a limit in shortening the distance between the heating furnace and the press machine.

[0006] The present invention has been made to solve the above-described problem, and suppresses a heat loss in conveyance of an aluminum alloy sheet that is a conveyance target.

Means of Solution to the Problem

[0007] According to the present invention, there is provided a production method comprising a heating step of heating an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance, to a temperature for enabling press forming in a state in which precipitation hardening is maintained, a conveyance step of storing the heated aluminum alloy sheet in a box body and conveying the aluminum alloy sheet in a state in which heated air is introduced into the box body to suppress temperature drop of the aluminum alloy sheet, and a pressing step of pressing the aluminum alloy sheet conveyed in the conveyance step.

[0008] In a configuration example of the production method, in the heating step, the aluminum alloy sheet that has undergone age hardening is heated within a range from not less than a solid solution start temperature to a hardness lowering temperature, in the conveyance step, the aluminum alloy sheet is conveyed at or above the solid solution start temperature, and in the pressing step, the aluminum alloy sheet is pressed at the solid solution start temperature.

[0009] In a configuration example of the production method, a conveyance apparatus that executes the conveyance step includes a conveyance mechanism, the box body which is fixed to the conveyance mechanism and stores the aluminum alloy sheet, an unloading/loading mechanism configured to unload the aluminum alloy sheet from the box body and load the aluminum alloy sheet into the box body, and a heating mechanism configured to introduce heated air into the box body to suppress temperature drop of the aluminum alloy sheet.

[0010] In a configuration example of the production method, the box body includes a first opening and a second opening provided in a surface facing the first opening, and the unloading/loading mechanism includes a conveyance arm that is arranged to extend through the box body between the first opening and the second opening, is movable in a penetrating direction to extend through the box body, and comprises a holding unit configured to hold the aluminum alloy sheet, and a first shielding plate and a second shielding plate, which are attached to the conveyance arm across the holding unit to shield the first opening and the second opening in a state in which the holding unit is stored in the box body.

[0011] In a configuration example of the production method, an inside of the box body is substantially sealed by shielding the first opening and the second opening with the first shielding plate and the second shielding plate.

[0012] In a configuration example of the production method, the first shielding plate is provided in a boundary

region between the holding unit and a region other than the holding unit, and comprises an opening/closing mechanism configured to open/close the second shielding plate.

[0013] In a configuration example of the production method, the conveyance arm includes two conveyance arms, and each of the two conveyance arms includes in the holding unit a hook that changes to a state in which the aluminum alloy sheet is held and an open state.

[0014] In a configuration example of the production method, the box body is formed by a lower box and an upper box, which are connected by a hinge so as to be opened/closed, and the unloading/loading mechanism includes two conveyance arms that are arranged while extending through the box body from a surface where the hinge is provided, are movable in a penetrating direction to extend through the box body, and can project from an opening/closing portion of the box body, and holding mechanisms provided on the two conveyance arms on a side of the opening/closing portion of the box body and configured to hold the aluminum alloy sheet between the two conveyance arms.

[0015] In a configuration example of the production method, the box body includes an opening, and the unloading/loading mechanism includes two conveyance arms stored in the box body in a state in which the conveyance arms are movable in a direction of discharging from the opening, two rods arranged to extend through the box body on a surface facing the opening and connected to the two conveyance arms to be movable in a direction of inserting/removing the two conveyance arms into/from the box body, a lid provided on the opening of the box body so as to be opened/closed and holding mechanisms that are provided on the two conveyance arms on a side of the opening of the box body and change, between the two conveyance arms, to a state in which the aluminum alloy sheet is held and an open state.

[0016] In a configuration example of the production method, an upper surface of the box body opens, and the unloading/loading mechanism includes a plate that is arranged on a side of the upper surface of the box body, is movable in a direction parallel to a bottom surface of the box body, and can close the upper surface opening of the box body, a first moving mechanism configured to move the plate in the direction parallel to the bottom surface of the box body between a first position and a second position, at which a relative position to the box body is different, a second moving mechanism configured to relatively move the box body and the plate to a state in which the plate closes the upper surface of the box body and an open state in each of a state at the first position and a state at the second position, and a holding mechanism provided on a lower surface of the plate on a side of the box body, which is in a region of the box body in the state at the first position and configured to change to a state in which the aluminum alloy sheet is held and an open state.

[0017] In a configuration example of the production

method, the box body has a double structure.

[0018] In a configuration example of the production method, the box body includes an exhaust port configured to exhaust air introduced by the heating mechanism.

[0019] In a configuration example of the production method, the conveyance apparatus further includes a cool air supply mechanism configured to mix cooled air with the air discharged from the exhaust port.

[0020] In a configuration example of the production method, the conveyance apparatus further includes a slow cooling box provided in a lower portion of the box body, and the cool air supply mechanism is provided in the slow cooling box.

[0021] In a configuration example of the production method, the conveyance apparatus includes a thermometer configured to measure a temperature in the box body, and a controller configured to control the heating mechanism based on a measurement result of the thermometer.

Effect of the Invention

[0022] As described above, according to the present invention, since an aluminum alloy sheet is stored in a box body heated to a predetermined temperature by a heating mechanism and conveyed, a heat loss in conveyance of the aluminum alloy sheet that is a conveyance target can be suppressed.

Brief Description of Drawings

[0023]

Fig. 1 is a flowchart for explaining a production method according to an embodiment of the present invention;

Fig. 2 is an explanatory view showing an example of a temperature profile in a heating step;

Fig. 3 is a view showing the configuration of a conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 4A is a plan view showing a partial configuration of the conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 4B is a plan view showing a partial configuration of the conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 5A is a sectional view showing a partial configuration of the conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 5B is a plan view showing a partial configuration of the conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 5C is a sectional view showing a partial configuration of the conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention;

Fig. 6A is a view showing the configuration of a conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 6B is a view showing the configuration of the conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 7A is a view showing the configuration of the conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 7B is a view showing the configuration of the conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 7C is a view showing the configuration of the conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 7D is a view showing the configuration of the conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention;

Fig. 8A is a view showing the configuration of a conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 8B is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9A is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9B is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9C is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9D is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9E is a view showing the configuration of the conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention;

Fig. 9F is a view showing the configuration of the conveyance apparatus of Example 3 used in the pro-

duction method according to the embodiment of the present invention;

Fig. 10A is a view showing the configuration of a conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 10B is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11A is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11B is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11C is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11D is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11E is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11F is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention;

Fig. 11G is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention; and

Fig. 11H is a view showing the configuration of the conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0024] A production method according to the embodiment of the present invention will now be described with reference to Fig. 1. The production method is a production method of pressing an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance, and includes a heating step S101, a conveyance step S102, and a pressing step S103.

[0025] In the heating step S101, an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance is heated to a temperature for enabling press forming in a state in which the precipitation hardening is maintained. For example, in the heating step S101, an aluminum alloy sheet that has undergone age

hardening is heated within the range from not less than a solid solution start temperature to a hardness lowering temperature. For example, an A7075 plate material (aluminum alloy sheet) formed by performing the precipitation hardening treatment to a T6 material or a T7 material is heated in a state in which the state of precipitation hardening treatment is maintained. For example, in the heating step S101, the aluminum alloy sheet is heated, for 3 to 70 sec, to any temperature within the range of 200°C to 250°C at which the aluminum alloy sheet can be press-formed.

[0026] In the conveyance step S102, the heated aluminum alloy sheet is stored in the box body of the above-described conveyance apparatus and conveyed in a state in which temperature drop of the conveyance apparatus is suppressed by introducing heated air into the box body. For example, in the conveyance step S102, the aluminum alloy sheet is conveyed at or above the solid solution start temperature.

[0027] In the pressing step S103, the aluminum alloy sheet conveyed in the conveyance step S102 is pressed. For example, in the pressing step S103, the aluminum alloy sheet is pressed at the solid solution start temperature.

[0028] According to the above-described production method, since an aluminum alloy sheet made of an aluminum alloy and having undergone the precipitation hardening treatment, which is manufactured by a plate material manufacturer, is heated in a state in which the state of precipitation hardening is maintained, and pressed while maintaining the state of precipitation hardening, the age hardening treatment is unnecessary after pressing in a parts manufacturer (car manufacturer). Age hardening of a pressed product requires a large heating facility and takes long time, and it is not suitable for the production speed of automobiles. However, if the age hardening treatment is unnecessary after pressing, as described above, the aluminum alloy that has undergone age hardening can be formed at low cost and high productivity in the parts manufacturer (car manufacturer).

[0029] However, in the conveyance step between the heating step and the pressing step, if the heated aluminum alloy sheet is simply conveyed to the press machine in the pressing step, the aluminum alloy sheet is cooled by air during this time and cannot therefore bend in the pressing step, and cracks may occur. If the heating temperature in the heating step is raised in anticipation of temperature drop of the aluminum alloy sheet due to air, the aluminum alloy sheet softens, and the hardness of the pressed product decreases in aging treatment of the T6 material or T7 material. For this reason, it is not preferable to raise the heating temperature in the heating step in anticipation of temperature drop. Note that this is more unpreferable for the T7 material because decrease of hardness is more conspicuous in the T7 material than in the T6 material.

[0030] As an example, the result of experiments of performing, for an aluminum alloy sheet made of an A7075-

T73 material and having a thickness of 2 mm, a heat treatment according to a temperature profile shown in Fig. 2 in the heating step and performing the pressing step will be shown.

[0031] If the heating step is performed at a maximum temperature of 255°C for a heating time of 45 sec, the hardness of a pressed product after pressing is 137 HV. If the heating step is performed at a maximum temperature of 230°C for a heating time of 45 sec, the hardness of a pressed product after pressing is 151 HV. If the heating step is performed at a maximum temperature of 225°C for a heating time of 25 sec, the hardness of a pressed product after pressing is 155 HV. If the heating step is performed at a maximum temperature of 195°C for a heating time of 30 sec, the hardness of a pressed product after pressing is 156 HV. If the heating step is performed at a maximum temperature of 195°C for a heating time of 10 sec, the hardness of a pressed product after pressing is 154 HV.

[0032] If the heating step is performed under a high temperature condition, pressing can easily be performed, but the hardness of the pressed product is low. Since a general management value of the hardness of the pressed product is 150 HV, in the above-described experiment result, the temperature of 255°C of the aluminum alloy sheet in the heating step is a condition that a pressed product complying with the product standard (management value) cannot be manufactured.

[0033] As described above, there is a limit in shortening the distance between the heating furnace and the press machine. After the heated aluminum alloy sheet is unloaded from the heating furnace, the unloaded aluminum alloy sheet is conveyed to the press machine. Since the temperature of the aluminum alloy sheet lowers during the conveyance, it is very important to suppress temperature drop of the aluminum alloy sheet at the time of conveyance. On the other hand, if the temperature in the heating step is made high in consideration of temperature drop during the conveyance, the hardness of a pressed product lowers, as is apparent from the above-described experiment result. For this reason, conveying the aluminum alloy sheet using the above-described conveyance apparatus while suppressing temperature drop is very effective in suppressing occurrence of a problem as described above. In particular, the T7 material is effective.

[Example 1]

[0034] A conveyance apparatus of Example 1 used in the production method according to the embodiment of the present invention will be described next with reference to Fig. 3. The conveyance apparatus includes a conveyance mechanism 101, and a box body 102 fixed to the conveyance mechanism 101. The conveyance mechanism 101 can be formed by a self-propelled vehicle driven by a motor or the like. The conveyance mechanism 101 can also be formed by, for example, a 6-axial robot. The conveyance mechanism 101 can also be

formed by a crane or a cylinder. The conveyance mechanism 101 can also be formed by a conveyance loader.

[0035] The box body 102 is a portion that stores an aluminum alloy sheet that is a conveyance object as a conveyance target, and includes, in Example 1, a first opening 103 and a second opening 104 provided in a surface facing the first opening 103. The box body 102 can be formed by an outer box 102a and an inner box 102b to have a double structure. The box body 102 (the outer box 102a and the inner box 102b) can be made of, for example, stainless steel or an aluminum alloy. The box body 102 (the outer box 102a and the inner box 102b) can also be made of ceramic.

[0036] Also, the conveyance apparatus includes an unloading/loading mechanism that unloads the aluminum alloy sheet that is the conveyance object from the box body 102 and loads it into the box body 102. In Example 1, the unloading/loading mechanism includes two conveyance arms 105. The two conveyance arms 105 are arranged to extend through the box body 102 between the first opening 103 and the second opening 104. Also, the two conveyance arms 105 are movable in a penetrating direction to extend through the box body 102, and includes a holding unit 121 that holds the aluminum alloy sheet as the conveyance target. The conveyance arms 105 can be made of, for example, stainless steel. For example, the conveyance arms 105 are slidable on the contact surfaces to the first opening 103 and the second opening 104. If a plurality of aluminum alloy sheets exist, the two conveyance arms 105 can include a plurality of sets.

[0037] For example, the conveyance arms 105 includes hooks 109 configured to hold the aluminum alloy sheet in the holding unit 121. The aluminum alloy sheet is, for example, a plate-shaped member having a rectangular shape whose sides have a length of 2,000 mm at maximum in a planar view. For example, in the holding unit 121, the hooks 109 are provided at the four corners of a rectangular region in a planar view sandwiched between the two conveyance arms 105. Also, a support structure (not shown) configured to hold the aluminum alloy sheet can be provided at the center between the two conveyance arms 105. The hooks 109 and the support structure can appropriately be provided in accordance with the size of the aluminum alloy sheet. In addition, the hooks 109 and the support structure can be detachable from the conveyance arms 105.

[0038] Also, a first shielding plate 106 and a second shielding plate 107 are attached to the conveyance arms 105 across the holding unit 121. The first shielding plate 106 is provided in a boundary region between the holding unit 121 and a region other than the holding unit 121. The second shielding plate 107 is provided at the distal end of the holding unit 121 in a direction of discharging the holding unit 121 from the box body 102. The first shielding plate 106 and the second shielding plate 107 can each be made of fluororubber, alumina-based ceramic, silica-based ceramic, zirconia-based ceramic, alu-

mina refractory brick, chamotte pottery, or the like. By the first shielding plate 106 and the second shielding plate 107, the first opening 103 and the second opening 104 can be shielded in a state in which the holding unit 121 is stored in the box body 102. When the first opening 103 and the second opening 104 are shielded by the first shielding plate 106 and the second shielding plate 107, the inside of the box body 102 is substantially sealed. Also, the first shielding plate 106 and the second shielding plate 107 can each include an opening/closing mechanism. The first shielding plate 106 and the second shielding plate 107 can be detachable together with the two conveyance arms 105.

[0039] Furthermore, the conveyance arms 105 are provided with a third shielding plate 110. The second shielding plate 107 and the third shielding plate 110 are arranged to be line-symmetrical across the first shielding plate 106. When the conveyance arms 105 are moved in the penetrating direction to extend through the box body 102, a first state (Fig. 4A) in which the holding unit 121 is unloaded to the outside of the box body 102 and a second state (Fig. 4B) in which the holding unit 121 is stored in the box body 102 (inner box 102b) can be obtained. The movement of the conveyance arms 105 can be executed, for example, manually. Alternatively, the movement of the conveyance arms 105 can be executed automatically using a predetermined driving mechanism.

[0040] In the first state shown in Fig. 4A, for example, an aluminum alloy sheet 151 heated in a heating furnace can be held on the holding unit 121 in the heating furnace. For example, first, the second shielding plate 107 is slid up to open by the opening/closing mechanism provided in the second shielding plate 107. In this state, the two conveyance arms 105 are inserted into the heating furnace. In a state in which the two conveyance arms 105 are inserted into the heating furnace, the third shielding plate 110 and the first shielding plate 106 shield the first opening 103 and the second opening 104, and the inside of the box body 102 (inner box 102b) is substantially sealed.

[0041] In the heating furnace in which the two conveyance arms 105 are inserted, the aluminum alloy sheet 151 is held on rods or the like. The aluminum alloy sheet 151 on the rods is taken from the portion where the second shielding plate 107 is open to the holding unit 121 between the two conveyance arms 105. The rods are lowered in this state, thereby placing the aluminum alloy sheet 151 on the hooks 109. In addition, the second shielding plate 107 is slid down and closed.

[0042] Also, the conveyance apparatus can include a mechanism that changes the hooks 109 provided on the two conveyance arms 105 of the holding unit 121 to a state in which the aluminum alloy sheet 151 is held and an open state. For example, in the heating furnace, the rods that hold the aluminum alloy sheet 151 are lowered, and in this state, the two conveyance arms 105 are inserted into the heating furnace. At this time, the aluminum alloy sheet 151 is arranged on the lower side of the hold-

ing unit 121 of the two conveyance arms 105. Next, the hooks 109 are set in the open state, and the rods are lifted to take the aluminum alloy sheet 151 to the holding unit 121. After that, the hooks 109 are set in a holding state, and the rods are lowered, thereby placing the aluminum alloy sheet 151 on the hooks 109 in the holding state.

[0043] In the second state shown in Fig. 4B, the aluminum alloy sheet 151 held by the holding unit is stored in the box body 102 (inner box 102b) together with the holding unit 121. In this state, the second shielding plate 107 and the first shielding plate 106 shield the first opening 103 and the second opening 104, and the inside of the box body 102 (inner box 102b) is substantially sealed.

[0044] Also, the conveyance apparatus includes a heating mechanism (heat retaining mechanism) 108 that introduces heated air into the box body 102 (inner box 102b) to suppress temperature drop of the stored aluminum alloy sheet. The heating mechanism 108 introduces air (hot air or warm air) heated (warmed) by the heating mechanism 108 into the box body 102, thereby heating the inside of the box body 102 (retaining heat). The heating mechanism 108 can be formed by, for example, "hot air heater QA type (QAO-135)" available from Nippon Heater. This can compress air outside the box body and make the air flow into an electric heater to generate heated air at a constant temperature and a constant flow rate. By an air layer between the outer box 102a and the inner box 102b of the box body 102 having a double structure, the heat retaining property in the internal space can be increased. Also, when the box body 102 has the double structure, in a state in which the inside of the inner box 102b is heated, the surface of the outer box 102a can keep a low-temperature state, and safety in the production site can be kept.

[0045] Also, as shown in Figs. 4A, 5A, and 5B, the box body 102 can include, at the center, an exhaust port 111 that exhausts the air (hot air or warm air) introduced along a side wall of the inner box 102b (heat retaining chamber or heating chamber) by the heating mechanism 108. Hence, the heated air spirally flows in the heat retaining chamber (inner box 102b), and is discharged from the exhaust port 111 to a cooling chamber (slow cooling box 112) below. In addition, the cooling chamber (slow cooling box 112) can further include a cool air supply mechanism that mixes cooled air (cold air or cool air) with the air (hot air or warm air) discharged from the exhaust port 111. This can prevent heated air from being discharged to the work site. The cool air supply mechanism can be provided in the slow cooling box 112 provided in the lower portion of the box body 102. Note that Fig. 5A shows a cross section taken along a line a - a' in Fig. 5B. The cool air supply mechanism includes a blower 113 extending through the box body, and a channel 114 that guides to the outlet of the exhaust port 111.

[0046] For example, warm air (heated air) supplied from the heating mechanism 108 flows in from a corner in the box body 102 along the wall surface, spirally cir-

culates in the box body 102 (heat retaining chamber or heating chamber), evenly heats the aluminum alloy sheet held by the holding unit 121, and is exhausted from the exhaust port 111 arranged at the center to the cooling chamber (slow cooling box 112). Cool air supplied from the blower 113 is transported via a channel 114 provided in the slow cooling box 112 using a guide or pipe having an L shape in a planar view, and mixed with the warm air discharged from the exhaust port 111 at the center to the cooling box 112. The discharge air slowly cooled by mixing the cool air is distributed to the left and right sides on the wall surface facing the channel 114, and discharged to the outside from a pair of left and right discharge ports 115 provided in the bottom portion of the slow cooling box 112.

[0047] As described above, the discharge ports 115 can be arranged at positions different from the exhaust port 111 in a planar view. The discharge ports 115 can be provided at a plurality of points on the wall surface sides from the central portion of the bottom portion of the slow cooling box 112 (on the outer sides from the channel 114). With this configuration, warm air is spirally applied, at a constant flow rate, to the plate-shaped aluminum alloy sheet placed in parallel to the bottom surface in the flat box body 102 having a rectangular shape in a planar view, thereby efficiently evenly heating the plate-shaped aluminum alloy sheet. In addition, since cool air is mixed, the temperature of the air discharged from the discharge ports 115 is lowered, and the environment in the press work site is not degraded.

[0048] As shown in Fig. 5C, a check valve 116 is provided, thereby forming a structure that prevents air (cooled air) from flowing back from the exhaust port 111 into the box body 102. Also, a silencer can be provided in each discharge port 115.

[0049] The conveyance apparatus can also include a thermometer 131 that measures the temperature in the box body 102, and a controller 132 that controls the heating mechanism 108 based on measurement result of the thermometer 131. The thermometer 131 is arranged, in the box body 102, at a point not to disturb the loading/unloading operation of the aluminum alloy sheet by the conveyance arms 105. The thermometer 131 can be provided, for example, on the bottom surface or the ceiling surface in the inner box 102b. For example, the thermometer 131 can be provided on the bottom surface or the ceiling surface in the inner box 102b in a region substantially corresponding to the central portion of the aluminum alloy sheet stored in the box body 102. With this configuration, the temperature in the box body 102 near the stored aluminum alloy sheet can be measured. The thermometer 131 can be formed by, for example, a thermocouple.

[0050] The controller 132 controls the operation of the heating mechanism 108 such that the measurement result of the thermometer reaches a set target temperature. For example, the correlation between the temperature measurement result of the thermometer 131 and the temperature of a stored aluminum alloy sheet is obtained by

experiments or the like, and the result is reflected on control by the controller 132, thereby enabling more accurate temperature control.

[0051] In the conveyance apparatus, first, in the first state shown in Fig. 4A, the aluminum alloy sheet 151 is held (loaded) on the holding unit 121. Next, the second state shown in Fig. 4B is set, and the holding unit 121 holding the aluminum alloy sheet 151 is stored in the box body 102 (inner box 102b) set to a predetermined temperature by the heating mechanism 108. Next, the conveyance mechanism 101 is operated to convey the aluminum alloy sheet 151 to a predetermined point (for example, a press machine). After that, the first state shown in Fig. 4A is set to allow the aluminum alloy sheet 151 to be extracted (unloaded) from the holding unit 121. Hence, according to the conveyance apparatus, since the aluminum alloy sheet 151 is stored in the box body 102 (inner box 102b) set at a predetermined temperature during conveyance from the heating step to the pressing step, a heat loss can be suppressed.

[0052] Also, in the conveyance apparatus, the inside of the box body 102 in which heat is retained (heated) at a predetermined temperature by the heating mechanism 108 is substantially sealed in both the first state shown in Fig. 4A and the second state shown in Fig. 4B. For this reason, even if the first state and the second state are switched when executing unloading/loading of the aluminum alloy sheet 151, a temperature variation in the box body 102 can be suppressed. For example, if the heating mechanism 108 is controlled by a control system formed by the thermometer 131 and the controller 132, a temperature change in the box body 102 during conveyance can be substantially eliminated. In particular, since heated air is introduced into the box body by the heating mechanism 108 to suppress temperature drop of the aluminum alloy sheet, even if a heat loss occurs due to opening/closing of the shielding plates or a non-sealed state of the box body, heated air including the heat loss amount is replenished, and therefore, a temperature variation in the box body 102 can be suppressed.

[0053] Earnest examinations of the present inventors revealed the followings. For example, when performing warm press, under the condition of a forming temperature of 200°C near the solid solution start temperature, for a material obtained by executing an age hardening treatment of T7 treatment for an A7000-based aluminum alloy sheet in advance, the press target plate material is heated in a heating furnace to an upper limit temperature of about 200°C to 250°C at which the hardness does not lower, extracted from the heating furnace, conveyed to a press machine in a state in which the plate material is in contact with ambient air, and press-formed. If the conveyance takes, for example, 20 sec, the temperature lowers by about 10°C to 15°C. If the temperature is lower than 200°C at which formation is possible, the press condition is not satisfied, and a formation failure occurs due to cracks, or the like.

[0054] Hence, heated air was introduced into the box body to suppress temperature drop of the aluminum alloy sheet. A state in which the temperature variation of the aluminum alloy sheet in the conveyance step from the heating step to the pressing step was almost zero was thus achieved. The box body need only have a size to store the aluminum alloy sheet. It is possible to reduce the heating energy of the heating mechanism, make the conveyance mechanism small, and maintain the temperature in the box body without increasing the cost.

[Example 2]

[0055] A conveyance apparatus of Example 2 used in the production method according to the embodiment of the present invention will be described next with reference to Figs. 6A and 6B. The conveyance apparatus includes a conveyance mechanism (not shown), and a box body 202 fixed to the conveyance mechanism. The conveyance mechanism is the same as in Example 1 described above and, for example, the box body 202 is fixed on the conveyance mechanism (not shown). As in Example 1 described above, the conveyance apparatus includes a heating mechanism (not shown) that introduces heated air into the box body 202 to suppress temperature drop of an aluminum alloy sheet. The heating mechanism introduces air (hot air or warm air) heated (warmed) by the heating mechanism into the box body 202, thereby heating the inside of the box body 202 (retaining heat).

[0056] The box body 202 is formed by a lower box 202a and an upper box 202b, which are connected by a hinge 203 so as to be opened/closed. The box body 202 has a double structure, and includes an inner lower box 206a and an inner upper box 206b inside the lower box 202a and the upper box 202b.

[0057] Also, the conveyance apparatus includes two conveyance arms 204 that are movable in a penetrating direction to extend through the box body 202. Note that Fig. 6A schematically shows a cross section parallel to a direction in which the two conveyance arms 204 extend, and Fig. 6B schematically shows a cross section perpendicular to the direction in which the two conveyance arms 204 extend. The two conveyance arms 204 are arranged while extending through the box body 202 from a surface where the hinge 203 is provided, and can project from the opening/closing portion of the box body 202. Also, the two conveyance arms 204 include holding mechanisms 205 configured to hold an aluminum alloy sheet 251 between the two conveyance arms 204. The holding mechanism 205 can be, for example, a clamp. The two conveyance arms 204 and the holding mechanisms 205 form an unloading/loading mechanism.

[0058] For example, as shown in Fig. 7A, after the lower box 202a and the upper box 202b are opened, the two conveyance arms 204 are slid in the direction of the opening/closing portion of the box body 202, and the two conveyance arms 204 are discharged from the opening/closing portion of the box body 202, as shown in Fig. 7B.

When the aluminum alloy sheet 251 is arranged at the discharge destination of the two conveyance arms 204, the holding mechanisms 205 can hold the aluminum alloy sheet 251. For example, the aluminum alloy sheet 251 heated in a heating furnace (not shown) can be held by the holding mechanisms 205 in the heating furnace.

[0059] As described above, for example, in a state in which the two conveyance arms 204 are discharged from the opening/closing portion of the box body 202, the two conveyance arms 204 are inserted into the heating furnace. In the heating furnace in which the two conveyance arms 204 are inserted, the aluminum alloy sheet 251 is held on rods (not shown) or the like. The aluminum alloy sheet 251 on the rods is arranged between the two conveyance arms 204 inserted, thereby holding the aluminum alloy sheet 251 by the holding mechanisms 205.

[0060] After the rods are lowered in this state, the two conveyance arms 204 are slid to the side of the hinge 203, as shown in Fig. 7C, thereby unloading the aluminum alloy sheet 251 held by the holding mechanisms 205 from the heating furnace and loading it into the box body 202. When the lower box 202a and the upper box 202b are closed in this state, the aluminum alloy sheet 251 can be stored, as shown in Fig. 7D. In this way, in a state in which the aluminum alloy sheet 251 is stored in the box body 202 that is in a heat retaining state, the conveyance mechanism (not shown) is operated to convey the aluminum alloy sheet 251 to, for example, a press machine.

[0061] After the aluminum alloy sheet 251 is conveyed to the press machine, the same procedures as in the setting of the open state of the lower box 202a and the upper box 202b and the sliding operation of the two conveyance arms 204 described with reference to Figs. 7A and 7B are performed, thereby loading the aluminum alloy sheet 251 held by the holding mechanisms 205 into the press machine. Hence, according to the conveyance apparatus, since the aluminum alloy sheet 251 is stored in the box body 202 set at a predetermined temperature during the conveyance, a heat loss can be suppressed.

[Example 3]

[0062] A conveyance apparatus of Example 3 used in the production method according to the embodiment of the present invention will be described next with reference to Figs. 8A and 8B. The conveyance apparatus includes a conveyance mechanism (not shown), and a box body 302 fixed to the conveyance mechanism. The conveyance mechanism is the same as in Examples 1 and 2 described above and, for example, the box body 302 is fixed on the conveyance mechanism (not shown). As in Example 1 described above, the conveyance apparatus includes a heating mechanism (not shown) that introduces heated air into the box body 302 to suppress temperature drop of an aluminum alloy sheet. The heating mechanism introduces air (hot air or warm air) heated (warmed) by the heating mechanism into the box body

302, thereby heating the inside of the box body 302 (retaining heat).

[0063] The box body 302 includes an opening 303. The box body 302 has a double structure, and includes an outer box 302a and an inner box 302b. The conveyance apparatus also includes two conveyance arms 304 stored in the box body 302 in a state in which the conveyance arms 304 are movable in a direction to discharge from the opening 303. Note that Fig. 8A schematically shows a cross section parallel to a direction in which the two conveyance arms 304 extend, and Fig. 8B schematically shows a cross section perpendicular to the direction in which the two conveyance arms 304 extend. The conveyance apparatus also includes two rods 305 arranged to extend through the box body 302 on a surface facing the opening 303 and connected to the two conveyance arms 304 to be movable in a direction of inserting/removing the two conveyance arms 304 into/from the box body 302. The two conveyance arms 304 and the two rods 305 form an unloading/loading mechanism.

[0064] The two conveyance arms 304 on the side of the opening 303 of the box body 302 include holding mechanisms 307. The holding mechanisms 307 change, between the two conveyance arms 304, to a state in which an aluminum alloy sheet 351 is held and an open state.

[0065] Also, the opening 303 of the box body 302 is provided with a lid 306 that can be opened/closed. For example, a wire 309 is connected to a wire fixing portion 308 fixed to the lid 306. Also, the wire 309 is wound on a fixed pulley 310 and connected to a wire winding mechanism (not shown). For example, the wire 309 is wound by the wire winding mechanism (not shown), thereby setting the lid 306 in the open state, as shown in Fig. 9A. In this state, the two rods 305 are pushed out by a moving mechanism (not shown), thereby discharging the two conveyance arms 304 from the box body 302.

[0066] As shown in Fig. 9B, when the aluminum alloy sheet 351 is arranged at the discharge destination of the two conveyance arms 304, the holding mechanisms 307 can hold the aluminum alloy sheet 351, as will be described later. For example, in a state in which the two conveyance arms 304 are discharged from the opening 303 of the box body 302, the two conveyance arms 304 are inserted into a heating furnace. In the heating furnace in which the two conveyance arms 304 are inserted, the aluminum alloy sheet 351 is held on rods 311, as shown in Fig. 9C. The aluminum alloy sheet 351 on the rods 311 is arranged between the two conveyance arms 304 inserted and, for example, the rods 311 are lowered, thereby holding the aluminum alloy sheet 351 by the holding mechanisms 307, as shown in Figs. 9D and 9E.

[0067] After the aluminum alloy sheet 351 is held by the holding mechanisms 307, the two rods 305 are pulled back by the moving mechanism (not shown), thereby pulling back the two conveyance arms 304 into the box body 302 (inner box 302b). In addition, the wire 309 is wound by the wire winding mechanism (not shown),

thereby closing the lid 306, as shown in Fig. 9F. This makes it possible to unload the aluminum alloy sheet 351 held by the holding mechanisms 307 from the heating furnace, load it into the box body 302 (inner box 302b), and store the aluminum alloy sheet 351 in the box body 302.

[0068] As described above, in a state in which the aluminum alloy sheet 351 is stored in the box body 302 in the heat retaining state, the conveyance mechanism (not shown) is operated to convey the aluminum alloy sheet 351 to, for example, a press machine.

[0069] After the aluminum alloy sheet 351 is conveyed to the press machine, the same procedures as in the opening operation of the lid 306 and the sliding operation of the two conveyance arms 304 described with reference to Figs. 9A and 9B are performed, thereby loading the aluminum alloy sheet 351 held by the holding mechanisms 307 into the press machine. Hence, according to the conveyance apparatus, since the aluminum alloy sheet 351 is stored in the box body 302 set at a predetermined temperature during the conveyance, a heat loss can be suppressed.

[Example 4]

[0070] A conveyance apparatus of Example 4 used in the production method according to the embodiment of the present invention will be described next with reference to Figs. 10A and 10B. The conveyance apparatus includes a conveyance mechanism (not shown), and a box body 402 fixed to the conveyance mechanism. The conveyance mechanism is the same as in Examples 1, 2, and 3 described above and, for example, the box body 402 is fixed on the conveyance mechanism (not shown).

[0071] In Example 4, an upper surface of the box body 402 opens. The box body 402 has a double structure, and includes an outer box 402a and an inner box 402b. Also, a plate 403 is arranged on the upper surface side of the box body 402. The plate 403 is movable in a direction parallel to the bottom surface of the box body 402 and can close the upper surface opening of the box body 402, and thus functions as a lid that closes the opening of the upper surface of the box body 402. Note that Fig. 10A schematically shows a cross section parallel to the moving direction of the plate 403 parallel to the bottom surface of the box body 402, and Fig. 10B schematically shows a cross section perpendicular to the moving direction of the plate 403 parallel to the bottom surface of the box body 402.

[0072] The plate 403 can be moved by a first moving mechanism (not shown) in the direction parallel to the bottom surface of the box body 402 between a first position and a second position, at which the relative position to the box body 402 is different. Also, the box body 402 and the plate 403 can be moved relatively by a second moving mechanism (not shown) to a state in which the plate 403 closes the upper surface of the box body 402 and an open state in each of the state at the first position

and the state at the second position described above.

[0073] Also, the conveyance apparatus includes holding mechanisms 404 on the lower surface of the plate 403 on the side of the box body 402, which is in the region of the box body 402 in the state at the first position. The holding mechanisms 404 change to a state in which an aluminum alloy sheet is held and an open state. The holding mechanisms 404 each include, for example, a hook 405.

[0074] As in Example 1 described above, the conveyance apparatus includes a heating mechanism (not shown) that introduces heated air into the box body 402 to suppress temperature drop of an aluminum alloy sheet. The heating mechanism introduces air (hot air or warm air) heated (warmed) by the heating mechanism into the box body 402, thereby heating the inside of the box body 402 (retaining heat).

[0075] For example, as shown in Fig. 11A, the plate 403 is raised and separated from the upper surface of the box body 402 by the second moving mechanism (not shown), thereby opening the box body 402. Next, the plate 403 is moved in the direction parallel to the bottom surface of the box body 402 by the first moving mechanism (not shown), and the plate 403 is lowered and brought into contact with the upper surface of the box body 402 by the second moving mechanism (not shown). Accordingly, as shown in Fig. 11B, the region of the plate 403 where the holding mechanisms 404 are provided is arranged outside the box body 402.

[0076] In this state, the region of the plate 403 where the holding mechanisms 404 are provided is inserted into a heating furnace. In the heating furnace in which the region of the plate 403 where the holding mechanisms 404 are provided is inserted, an aluminum alloy sheet 451 is held on rods (not shown), as shown in Fig. 11C. The aluminum alloy sheet 451 on the rods is arranged on the lower side of the inserted region of the plate 403 where the holding mechanisms 404 are provided, and the holding mechanisms 404 are opened.

[0077] The holding mechanisms 404 are opened, the box body 402 and the plate 403 are lowered by, for example, the conveyance mechanism, the holding mechanisms 404 are arranged on both sides of the aluminum alloy sheet 451, and the aluminum alloy sheet 451 is held by the holding mechanisms 404, as shown in Figs. 11D and 11E.

[0078] After the aluminum alloy sheet 451 is held by the holding mechanisms 404, the plate 403 is raised and separated from the upper surface of the box body 402 by the second moving mechanism (not shown) (Fig. 11F). Next, the plate 403 is moved in the direction parallel to the bottom surface of the box body 402 by the first moving mechanism (not shown), thereby moving the region of the plate 403 where the holding mechanisms 404 are provided to the upper side of the box body 402 (Fig. 11G). Furthermore, the plate 403 is lowered and brought into contact with the upper surface of the box body 402 by the second moving mechanism (not shown). According-

ly, as shown in Fig. 11H, the aluminum alloy sheet 451 held by the holding mechanisms 404 can be unloaded from the heating furnace and loaded into the box body 402 (inner box 402b), and the aluminum alloy sheet 451 can be stored in the box body 402.

[0079] In a state in which the aluminum alloy sheet 451 is stored in the box body 402 that is in a heat retaining state, as described above, the conveyance mechanism (not shown) is operated to convey the aluminum alloy sheet 451 to, for example, a press machine.

[0080] After the aluminum alloy sheet 451 is conveyed to the press machine, the same procedures as in the rising operation and the sliding operation of the lid 306 described with reference to Figs. 11A and 11B are performed, thereby loading the aluminum alloy sheet 451 held by the holding mechanisms 404 into the press machine. Hence, according to the conveyance apparatus, since the aluminum alloy sheet 451 is stored in the box body 402 set at a predetermined temperature during the conveyance, a heat loss can be suppressed.

[0081] Note that in the above-described heating step, a contact heating furnace can be used. The contact heating furnace has high heat uniformity and can easily handle blank shapes in various sizes. Since the facility is simple, mass productivity can be obtained. The contact heating furnace is suitable for heating an aluminum alloy sheet that has undergone age hardening to a press forming temperature without lowering the hardness.

[0082] In the contact heating furnace, upper and lower plates that are made close/separated by a servomotor while sandwiching a work therebetween, and are load-value-controlled and temperature-controlled can be installed. Since the work is constantly heated from both surfaces by the plates that are in contact with the work, rapid heating can evenly be performed, and thermal effect (hardness decrease) to the work can be minimized.

[0083] A plurality of box bodies and a plurality of heating furnaces can be aligned in parallel and arranged. The press time is shorter than the heating time (in the examples, the heating time is 60 sec, and the bottom dead center holding time is 10 sec). For this reason, if a plurality of apparatuses that take time are prepared, the production speed can be improved in total. Since the apparatuses are aligned in parallel, the space efficiency can be increased, and rationalization of conveyance is possible.

[0084] As described above, according to the present invention, since the aluminum alloy sheet is stored in the box body set at a predetermined temperature by the heating mechanism and conveyed, a heat loss in the conveyance of the aluminum alloy sheet as the conveyance target can be suppressed. Hence, the aluminum alloy sheet that has undergone a precipitation hardening treatment to increase the strength/hardness in advance can be hot-pressed without lowering its strength/hardness. In addition, since the age hardening treatment in the press site is unnecessary, the productivity does not lower.

[0085] By the conveyance step in which the heated aluminum alloy sheet is stored in the box body and con-

veyed in a state in which heated air is introduced into the box body to suppress temperature drop of the aluminum alloy sheet, temperature drop during the conveyance can be suppressed even if the heating temperature in the heating step that is a preprocess falls within a narrow temperature range (200°C to 250°C in a 7000-based T7 process) from an upper limit temperature at which the hardness does not lower to a lower limit temperature at which press forming is possible. Hence, in the pressing step that is the next process, press forming can be performed without lowering the hardness. Since the precipitation hardening treatment is performed in advance for the material before the heating step, the artificial age hardening treatment in the pressing site is unnecessary, and a lightweight vehicle body part having a high hardness (strength) can be obtained without a decrease of the production speed. In addition, since heated air is introduced into the box body, a heat loss caused by inserting/removing the aluminum alloy sheet into/from the box body can be compensated for, and the temperature can be controlled to a constant temperature.

[0086] Some or all of the above-described embodiments can also be described as in the following supplementary notes but are not limited to the followings.

[Supplementary Note 1]

[0087] There is provided a production method comprising:

a heating step of heating an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance, to a temperature for enabling press forming in a state in which precipitation hardening is maintained;

a conveyance step of storing the heated aluminum alloy sheet in a box body and conveying the aluminum alloy sheet in a state in which heated air is introduced into the box body to suppress temperature drop of the aluminum alloy sheet; and

a pressing step of pressing the aluminum alloy sheet conveyed in the conveyance step.

[Supplementary Note 2]

[0088] In the production method according to Supplementary Note 1,

in the heating step, the aluminum alloy sheet that has undergone age hardening is heated within a range from not less than a solid solution start temperature to a hardness lowering temperature, in the conveyance step, the aluminum alloy sheet is conveyed at or above the solid solution start temperature, and

in the pressing step, the aluminum alloy sheet is pressed at the solid solution start temperature.

[Supplementary Note 3]

[0089] In the production method according to Supplementary Note 1 or 2, a conveyance apparatus that executes the conveyance step includes:

a conveyance mechanism;
the box body which is fixed to the conveyance mechanism and stores the aluminum alloy sheet;
an unloading/loading mechanism configured to unload the aluminum alloy sheet from the box body and load the aluminum alloy sheet into the box body; and
a heating mechanism configured to introduce heated air into the box body to suppress temperature drop of the aluminum alloy sheet.

[Supplementary Note 4]

[0090] In the production method according to Supplementary Note 3,

the box body includes a first opening and a second opening provided in a surface facing the first opening, and
the unloading/loading mechanism includes:

a conveyance arm that is arranged to extend through the box body between the first opening and the second opening, is movable in a penetrating direction to extend through the box body, and comprises a holding unit configured to hold the aluminum alloy sheet; and
a first shielding plate and a second shielding plate, which are attached to the conveyance arm across the holding unit to shield the first opening and the second opening in a state in which the holding unit is stored in the box body.

[Supplementary Note 5]

[0091] In the production method according to Supplementary Note 4, an inside of the box body is substantially sealed by shielding the first opening and the second opening with the first shielding plate and the second shielding plate.

[Supplementary Note 6]

[0092] In the production method according to Supplementary Note 4 or 5, the first shielding plate is provided in a boundary region between the holding unit and a region other than the holding unit, and comprises an opening/closing mechanism configured to open/close the second shielding plate.

[Supplementary Note 7]

[0093] In the production method according to any one of Supplementary Notes 4 to 6, the conveyance arm includes two conveyance arms, and each of the two conveyance arms includes in the holding unit a hook that changes to a state in which the aluminum alloy sheet is held and an open state.

[Supplementary Note 8]

[0094] In the production method according to Supplementary Note 3,

the box body is formed by a lower box and an upper box, which are connected by a hinge so as to be opened/closed, and
the unloading/loading mechanism includes:

two conveyance arms that are arranged while extending through the box body from a surface where the hinge is provided, are movable in a penetrating direction to extend through the box body, and can project from an opening/closing portion of the box body; and
holding mechanisms provided on the two conveyance arms on a side of the opening/closing portion of the box body and configured to hold the aluminum alloy sheet between the two conveyance arms.

[Supplementary Note 9]

[0095] In the production method according to Supplementary Note 3,

the box body includes an opening, and
the unloading/loading mechanism includes:

two conveyance arms stored in the box body in a state in which the conveyance arms are movable in a direction of discharging from the opening;
two rods arranged to extend through the box body on a surface facing the opening and connected to the two conveyance arms to be movable in a direction of inserting/removing the two conveyance arms into/from the box body;
a lid provided on the opening of the box body so as to be opened/closed; and
holding mechanisms that are provided on the two conveyance arms on a side of the opening of the box body and change, between the two conveyance arms, to a state in which the aluminum alloy sheet is held and an open state.

[Supplementary Note 10]

[0096] In the production method according to Supplementary Note 3,

an upper surface of the box body opens, and the unloading/loading mechanism includes:

a plate that is arranged on a side of the upper surface of the box body, is movable in a direction parallel to a bottom surface of the box body, and can close the upper surface opening of the box body;

a first moving mechanism configured to move the plate in the direction parallel to the bottom surface of the box body between a first position and a second position, at which a relative position to the box body is different;

a second moving mechanism configured to relatively move the box body and the plate to a state in which the plate closes the upper surface of the box body and an open state in each of a state at the first position and a state at the second position; and

a holding mechanism provided on a lower surface of the plate on a side of the box body, which is in a region of the box body in the state at the first position and configured to change to a state in which the aluminum alloy sheet is held and an open state.

[Supplementary Note 11]

[0097] In the production method according to any one of Supplementary Notes 3 to 10, the box body has a double structure.

[Supplementary Note 12]

[0098] In the production method according to any one of Supplementary Notes 3 to 11, the box body includes an exhaust port configured to exhaust air introduced by the heating mechanism.

[Supplementary Note 13]

[0099] In the production method according to Supplementary Note 12, the conveyance apparatus further includes a cool air supply mechanism configured to mix cooled air with the air discharged from the exhaust port.

[Supplementary Note 14]

[0100] In the production method according to Supplementary Note 13, the conveyance apparatus further includes a slow cooling box provided in a lower portion of the box body, and the

cool air supply mechanism is provided in the slow cooling box.

[Supplementary Note 15]

[0101] In the production method according to any one of Supplementary Notes 3 to 14, the conveyance apparatus includes:

a thermometer configured to measure a temperature in the box body; and

a controller configured to control the heating mechanism based on a measurement result of the thermometer.

[0102] Note that the present invention is not limited to the above-described embodiment, and it is obvious that various modifications and combinations can be made by those who have normal knowledge in the field without departing from the technical scope of the present invention.

Explanation of the Reference Numerals and Signs

[0103] 101... conveyance mechanism, 102...box body, 102a...outer box, 102b...inner box, 103...first opening, 104...second opening, 105 ... conveyance arm, 106...first shielding plate, 107...second shielding plate, 108...heating mechanism, 110...third shielding plate, 121...holding unit, 151...aluminum alloy sheet

Claims

1. A production method comprising:

a heating step of heating an aluminum alloy sheet that has undergone a precipitation hardening treatment in advance, to a temperature for enabling press forming in a state in which precipitation hardening is maintained;
a conveyance step of storing the heated aluminum alloy sheet in a box body and conveying the aluminum alloy sheet in a state in which heated air is introduced into the box body to suppress temperature drop of the aluminum alloy sheet; and
a pressing step of pressing the aluminum alloy sheet conveyed in the conveyance step.

2. The production method according to claim 1, wherein

in the heating step, the aluminum alloy sheet that has undergone age hardening is heated within a range from not less than a solid solution start temperature to a hardness lowering temperature,
in the conveyance step, the aluminum alloy

sheet is conveyed at or above the solid solution start temperature, and
in the pressing step, the aluminum alloy sheet is pressed at the solid solution start temperature.

3. The production method according to claim 1, wherein a conveyance apparatus that executes the conveyance step includes:

a conveyance mechanism;
the box body which is fixed to the conveyance mechanism and stores the aluminum alloy sheet;
an unloading/loading mechanism configured to unload the aluminum alloy sheet from the box body and load the aluminum alloy sheet into the box body; and
a heating mechanism configured to introduce heated air into the box body to suppress temperature drop of the aluminum alloy sheet.

4. The production method according to claim 3, wherein

the box body includes a first opening and a second opening provided in a surface facing the first opening, and
the unloading/loading mechanism includes:

a conveyance arm that is arranged to extend through the box body between the first opening and the second opening, is movable in a penetrating direction to extend through the box body, and comprises a holding unit configured to hold the aluminum alloy sheet; and
a first shielding plate and a second shielding plate, which are attached to the conveyance arm across the holding unit to shield the first opening and the second opening in a state in which the holding unit is stored in the box body.

5. The production method according to claim 4, wherein an inside of the box body is substantially sealed by shielding the first opening and the second opening with the first shielding plate and the second shielding plate.

6. The production method according to claim 4, wherein the first shielding plate is provided in a boundary region between the holding unit and a region other than the holding unit, and comprises an opening/closing mechanism configured to open/close the second shielding plate.

7. The production method according to claim 4, wherein the conveyance arm includes two conveyance arms, and each of the two conveyance arms includes in

the holding unit a hook that changes to a state in which the aluminum alloy sheet is held and an open state.

8. The production method according to claim 3, wherein

the box body is formed by a lower box and an upper box, which are connected by a hinge so as to be opened/closed, and
the unloading/loading mechanism includes:

two conveyance arms that are arranged while extending through the box body from a surface where the hinge is provided, are movable in a penetrating direction to extend through the box body, and can project from an opening/closing portion of the box body; and
holding mechanisms provided on the two conveyance arms on a side of the opening/closing portion of the box body and configured to hold the aluminum alloy sheet between the two conveyance arms.

9. The production method according to claim 3, wherein

the box body includes an opening, and
the unloading/loading mechanism includes:

two conveyance arms stored in the box body in a state in which the conveyance arms are movable in a direction of discharging from the opening;
two rods arranged to extend through the box body on a surface facing the opening and connected to the two conveyance arms to be movable in a direction of inserting/removing the two conveyance arms into/from the box body;
a lid provided on the opening of the box body so as to be opened/closed; and
holding mechanisms that are provided on the two conveyance arms on a side of the opening of the box body and change, between the two conveyance arms, to a state in which the aluminum alloy sheet is held and an open state.

10. The production method according to claim 3, wherein

an upper surface of the box body opens, and
the unloading/loading mechanism includes:

a plate that is arranged on a side of the upper surface of the box body, is movable in a direction parallel to a bottom surface of the box body, and can close the upper surface opening of the box body;

- a first moving mechanism configured to move the plate in the direction parallel to the bottom surface of the box body between a first position and a second position, at which a relative position to the box body is different; 5
- a second moving mechanism configured to relatively move the box body and the plate to a state in which the plate closes the upper surface of the box body and an open state in each of a state at the first position and a state at the second position; and 10
- a holding mechanism provided on a lower surface of the plate on a side of the box body, which is in a region of the box body in the state at the first position and configured to change to a state in which the aluminum alloy sheet is held and an open state. 15
11. The production method according to any one of claims 3 to 10, wherein the box body has a double structure. 20
12. The production method according to any one of claims 3 to 10, wherein the box body includes an exhaust port configured to exhaust air introduced by the heating mechanism. 25
13. The production method according to claim 12, wherein the conveyance apparatus further includes a cool air supply mechanism configured to mix cooled air with the air discharged from the exhaust port. 30
14. The production method according to claim 13, wherein the conveyance apparatus further includes a slow cooling box provided in a lower portion of the box body, and the cool air supply mechanism is provided in the slow cooling box. 35 40
15. The production method according to any one of claims 3 to 10, wherein the conveyance apparatus includes: 45
- a thermometer configured to measure a temperature in the box body; and
- a controller configured to control the heating mechanism based on a measurement result of the thermometer. 50

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FIG.1

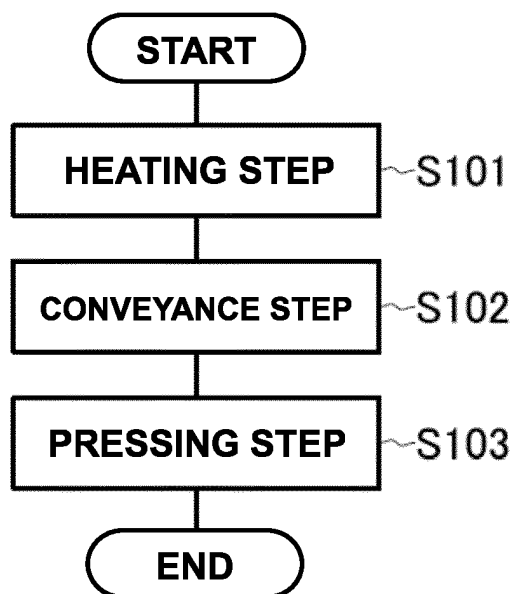


FIG.2

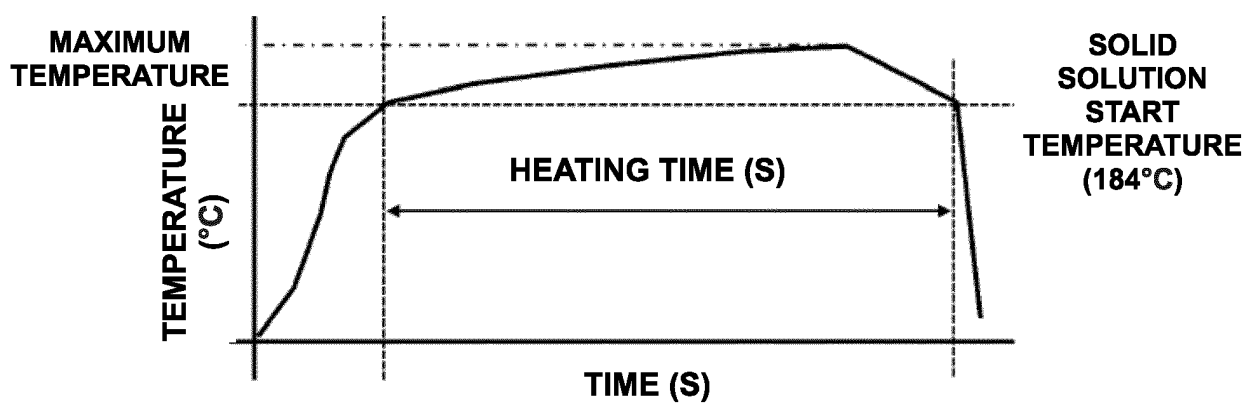


FIG.3

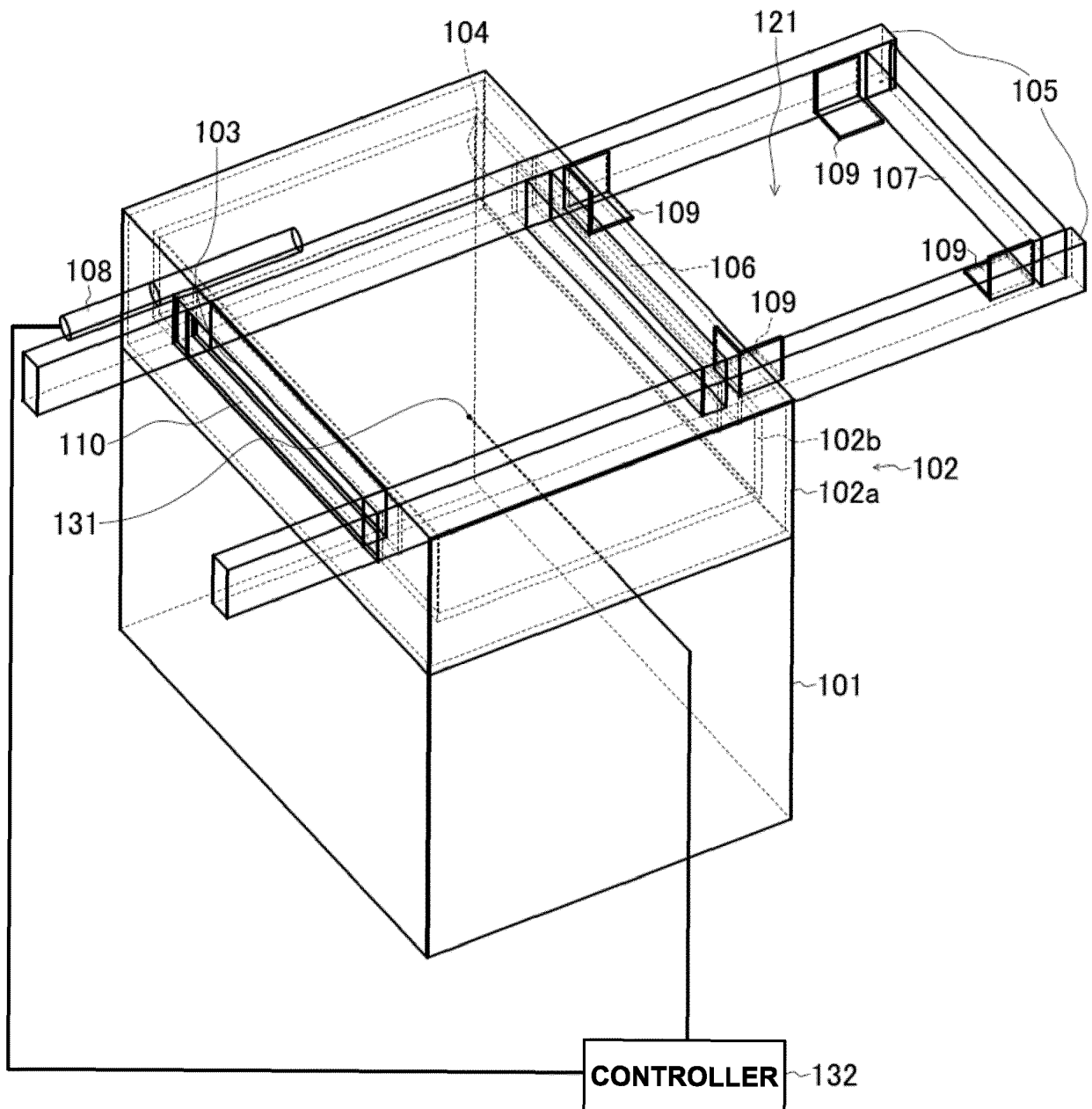


FIG.4A

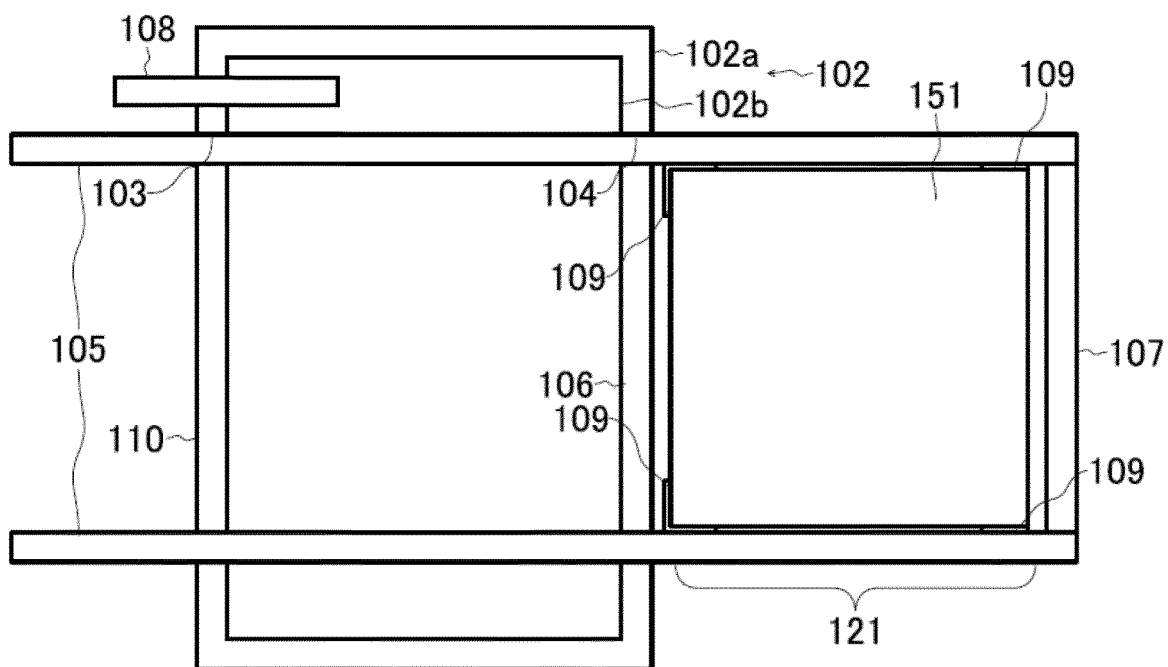


FIG.4B

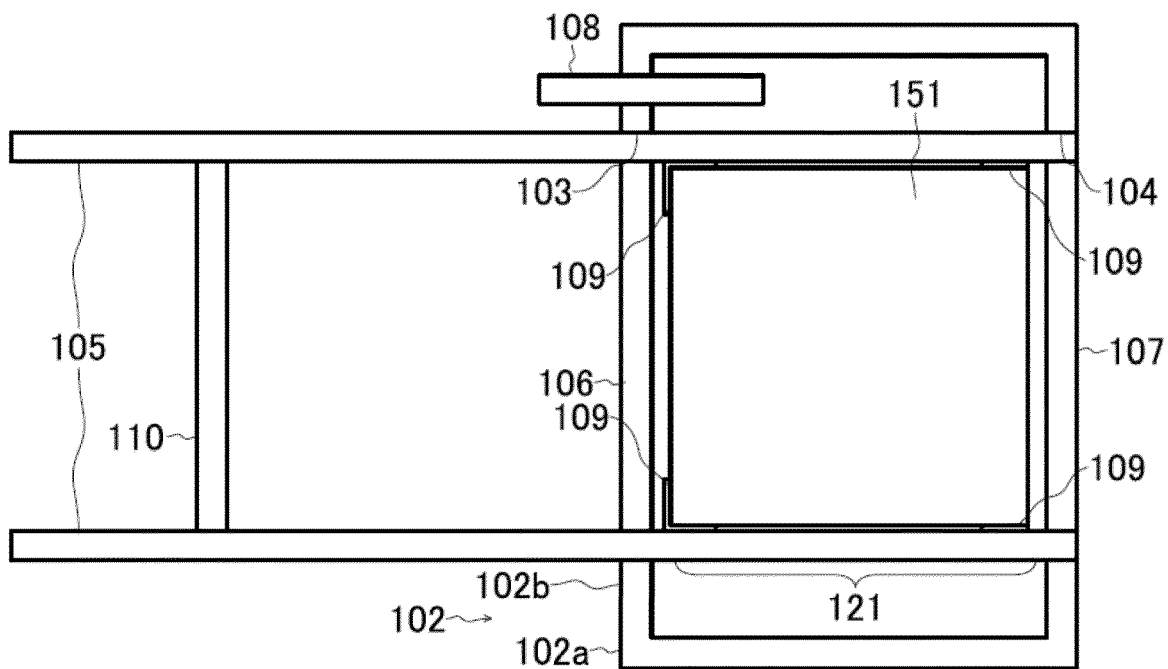


FIG.5A

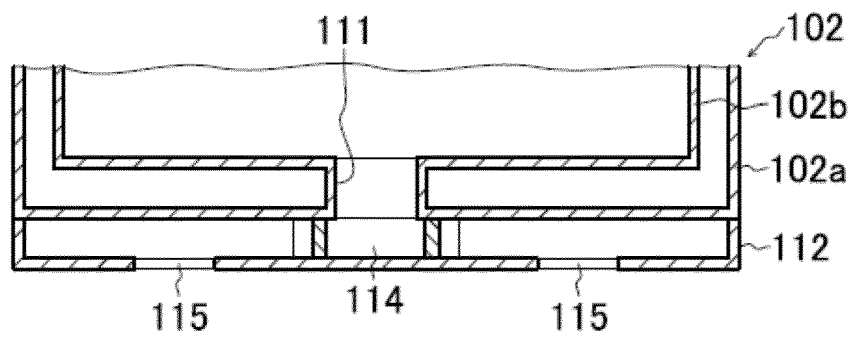


FIG.5B

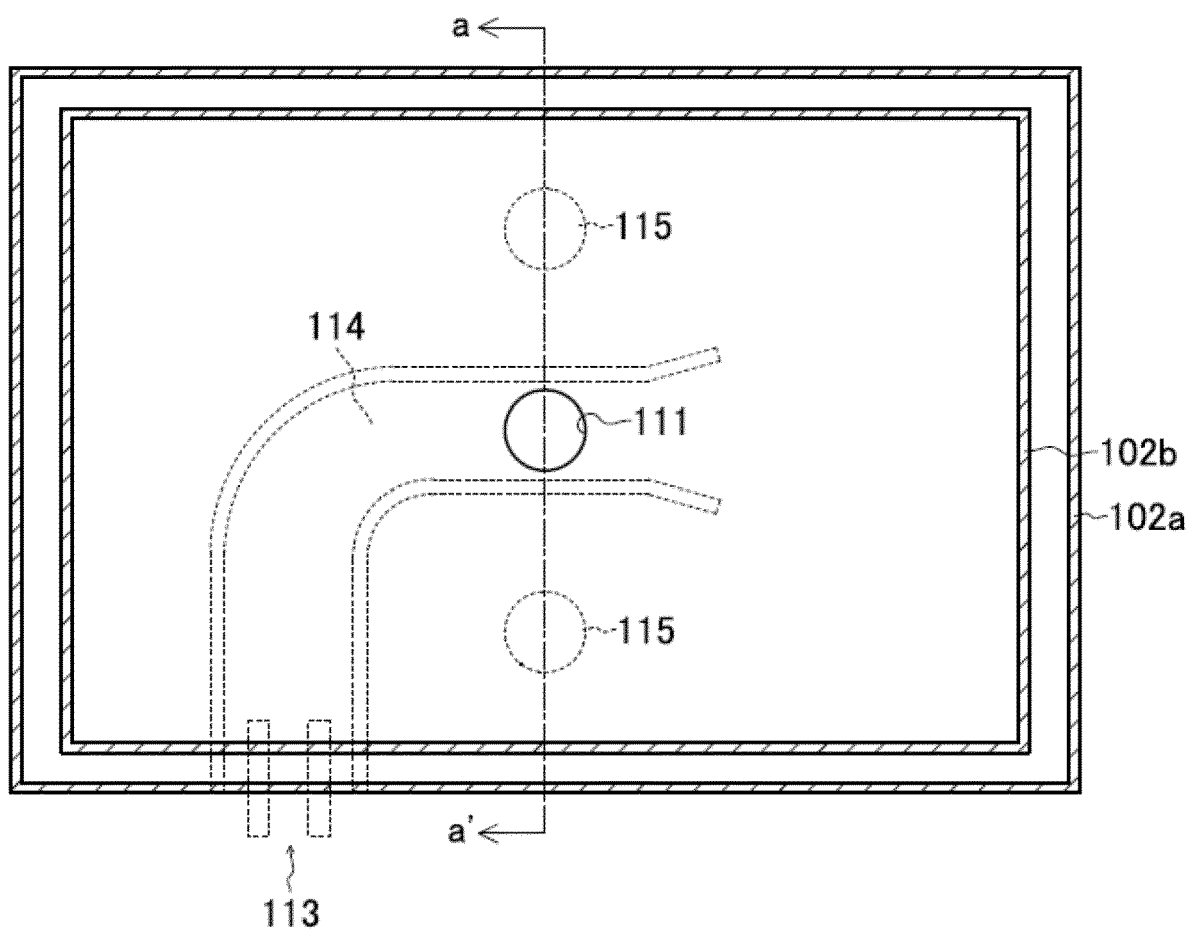


FIG.5C

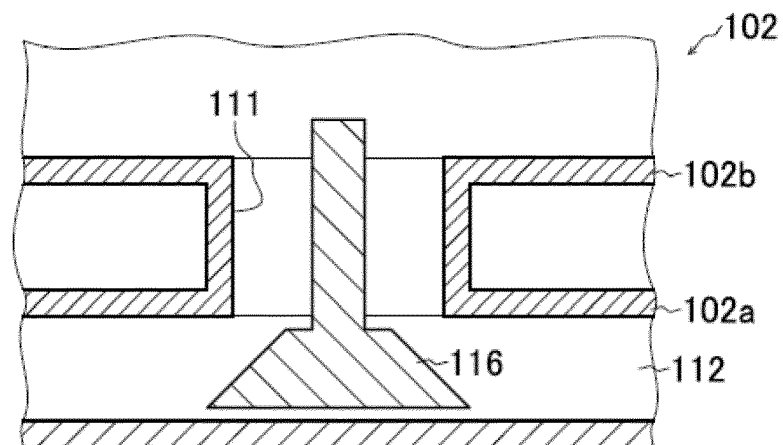


FIG.6A

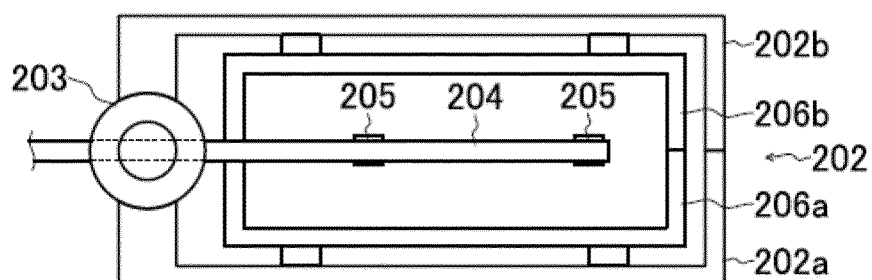


FIG.6B

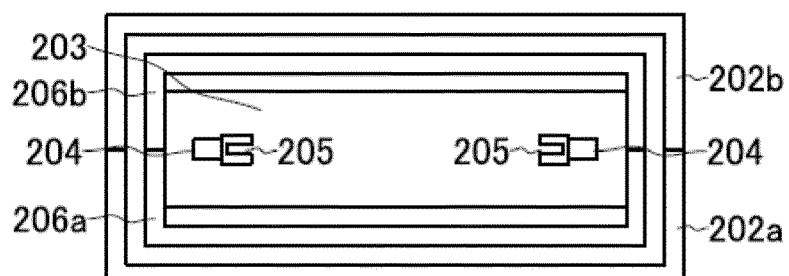


FIG.7A

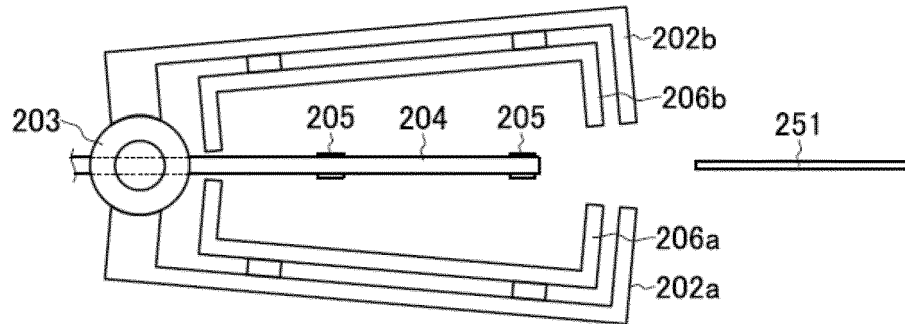


FIG.7B

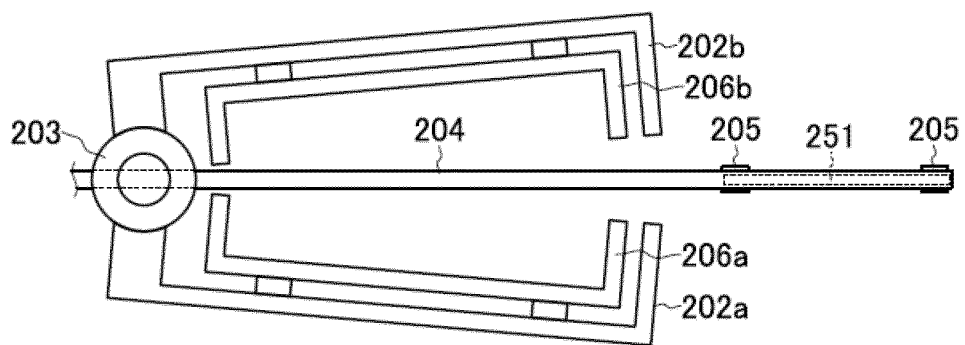


FIG.7C

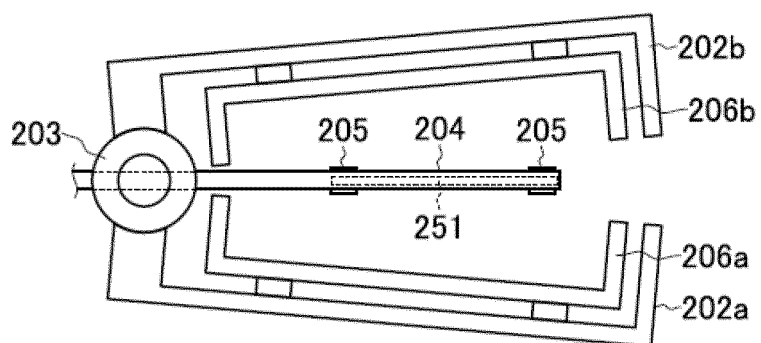


FIG.7D

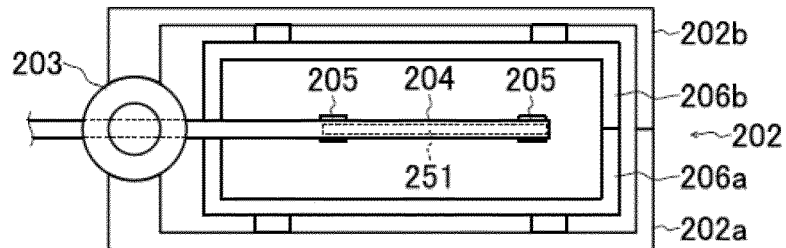


FIG.8A

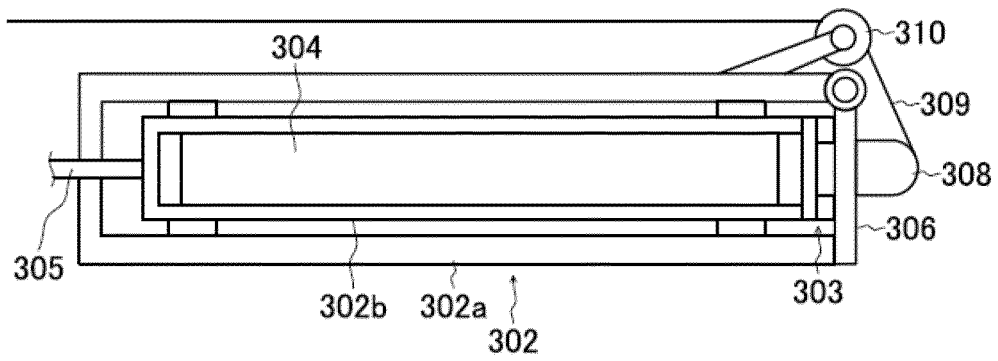


FIG.8B

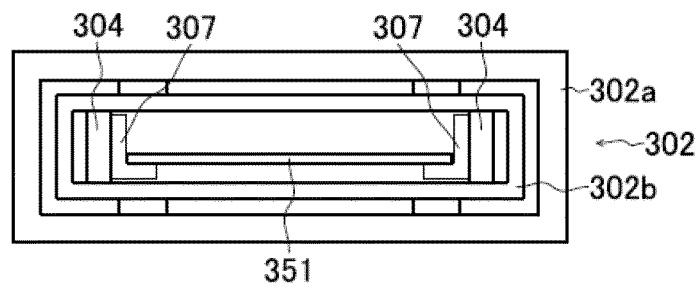


FIG.9A

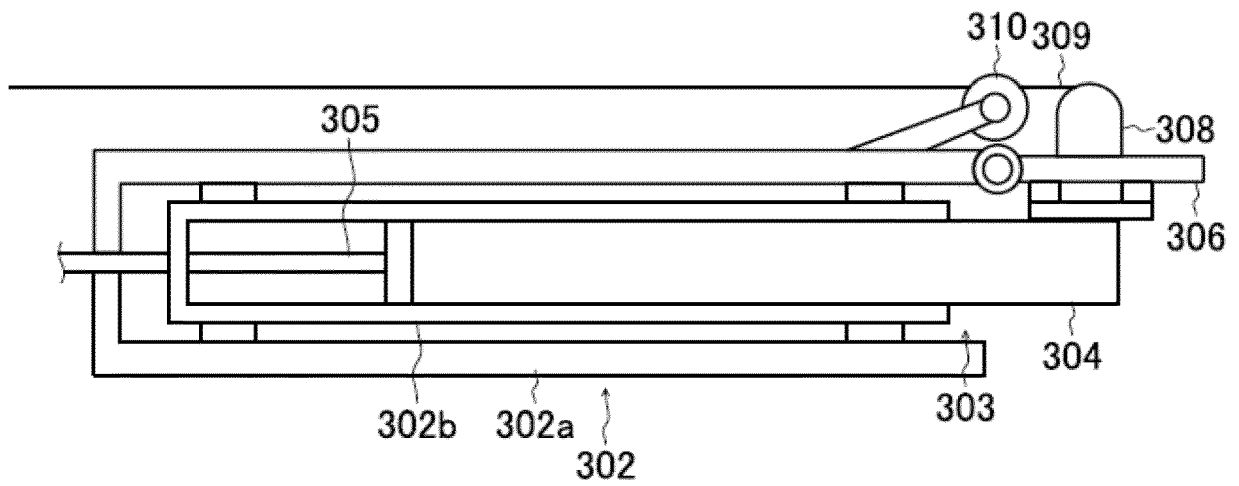


FIG.9B

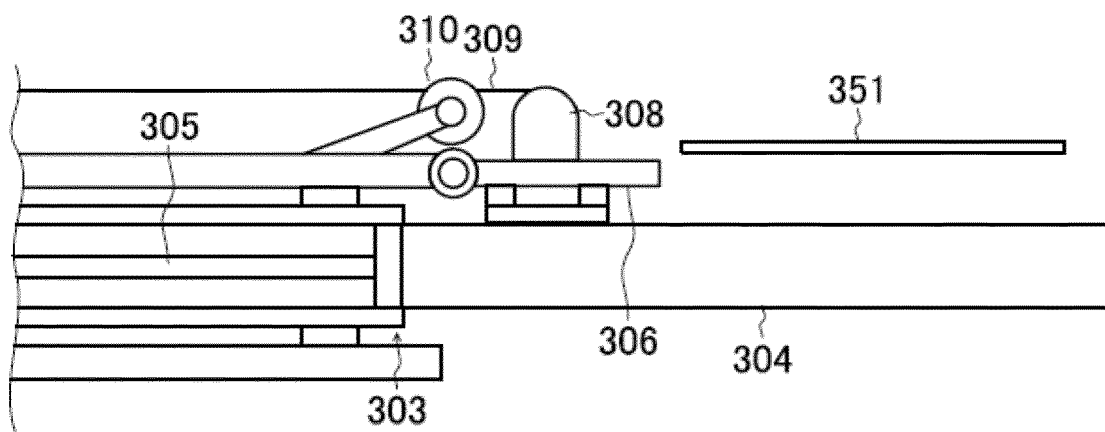


FIG.9C

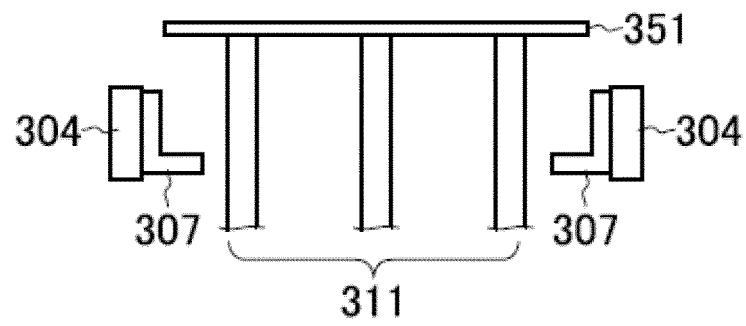


FIG.9D

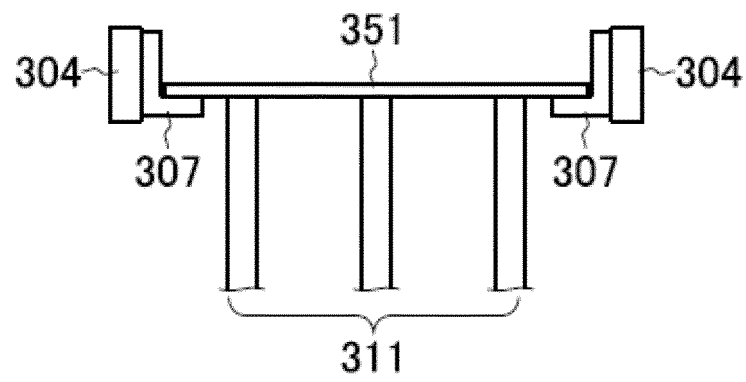


FIG.9E

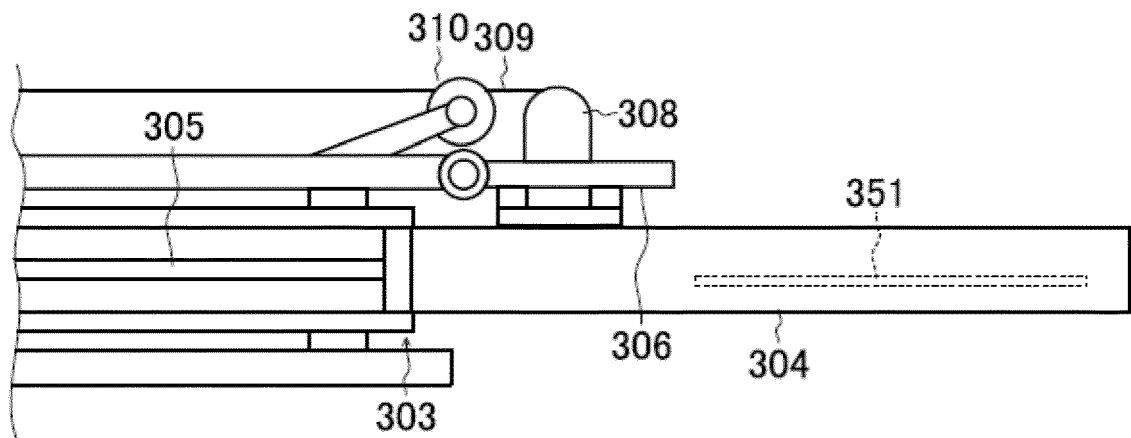


FIG.9F

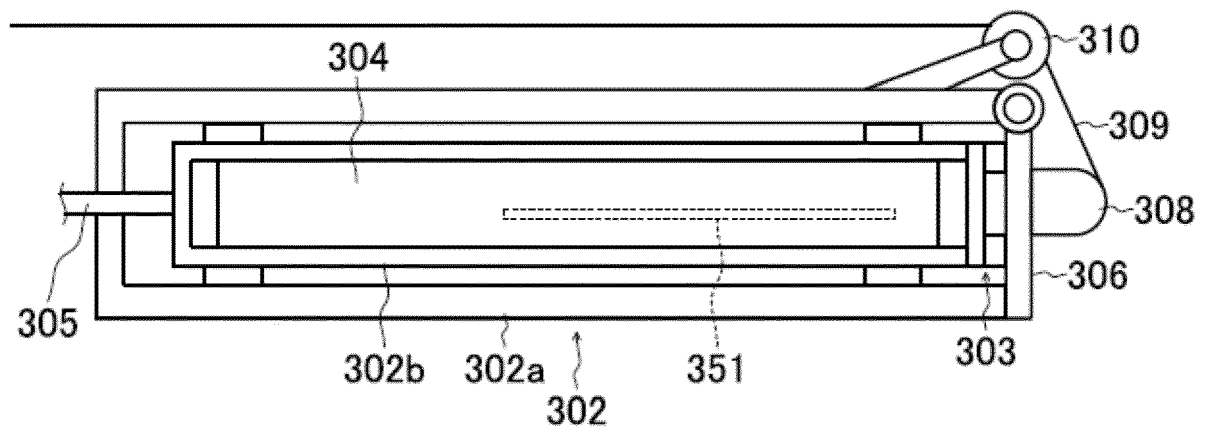


FIG.10A

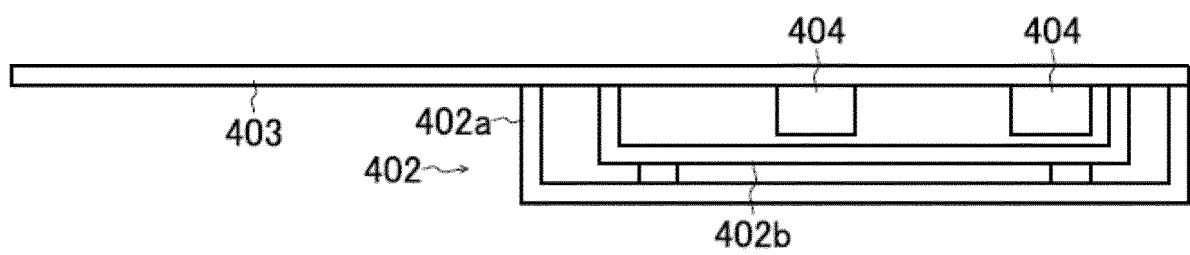


FIG.10B

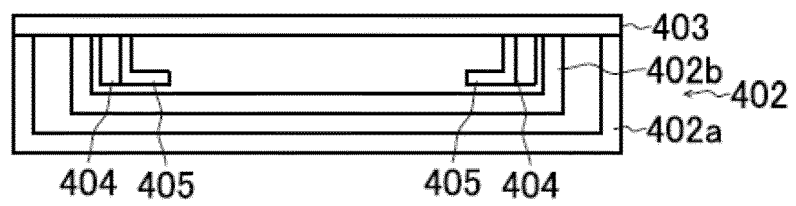


FIG.11A

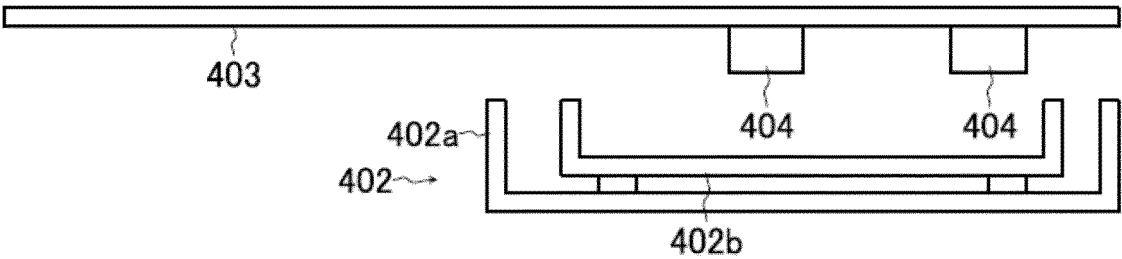


FIG.11B

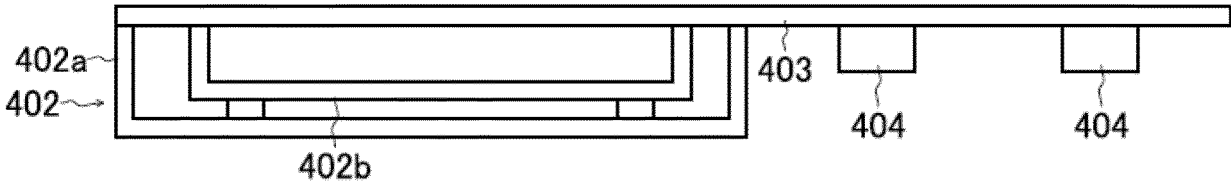


FIG.11C

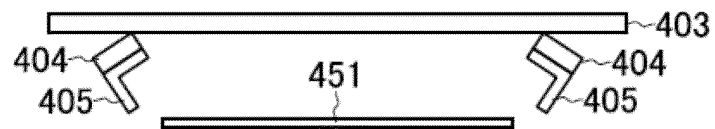


FIG.11D

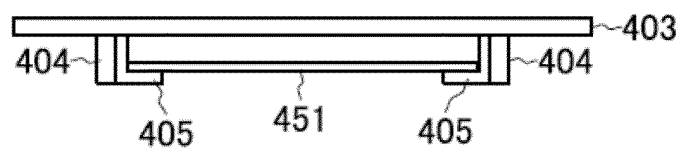


FIG.11E

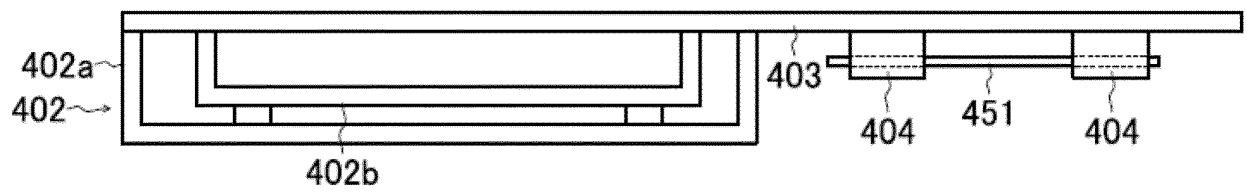


FIG.11F

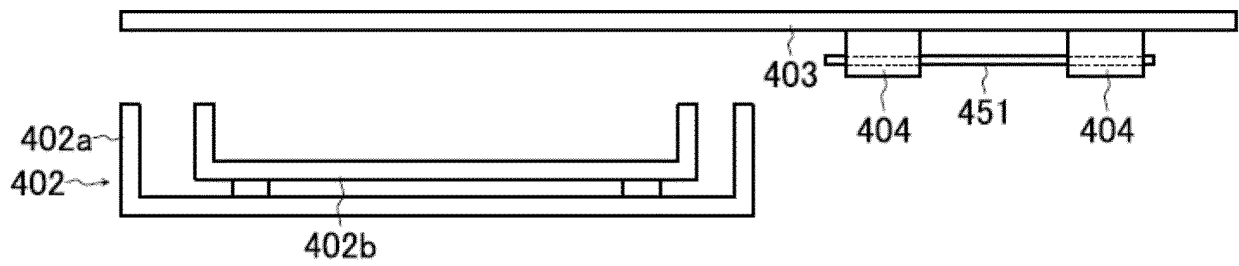


FIG.11G

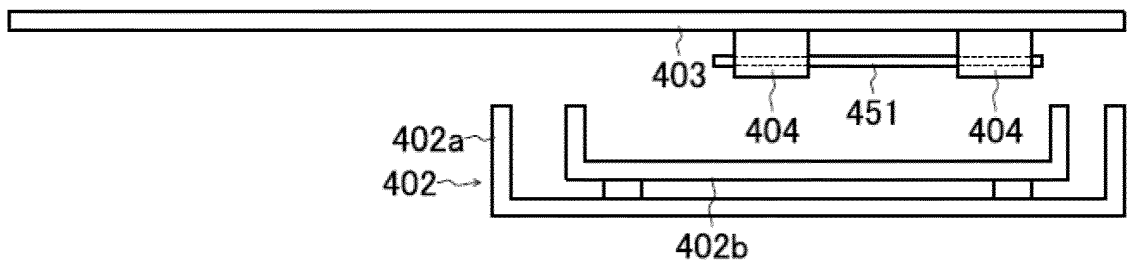
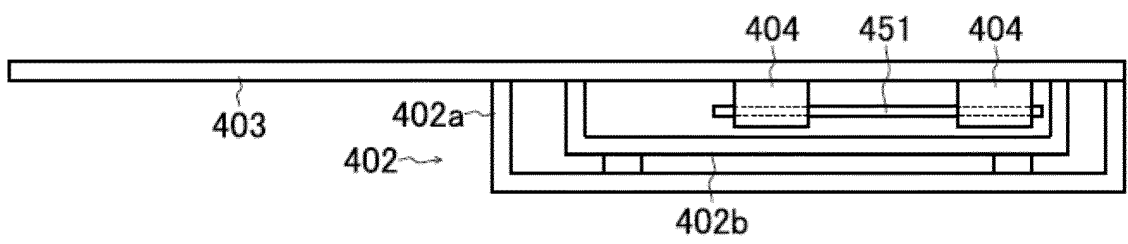


FIG.11H



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/033104

A. CLASSIFICATION OF SUBJECT MATTER

B21D 22/20(2006.01)i; **B21D 43/00**(2006.01)i; **B65G 49/00**(2006.01)i; **C21D 1/00**(2006.01)i; **F27D 3/06**(2006.01)i;
F27D 3/12(2006.01)i

FI: B21D22/20 H; B21D43/00 J; B65G49/00 Z; C21D1/00 E; F27D3/06 B; F27D3/12 Z

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D22/20; B21D43/00; B65G49/00; C21D1/00; F27D3/06; F27D3/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, Y	WO 2022/045069 A1 (NIPPON STEEL CORP.) 03 March 2022 (2022-03-03) paragraphs [0013]-[0143], fig. 1-21	1-3, 11-13, 15
P, A		4-10, 14
Y	JP 2021-62407 A (G-TEKT CORP.) 22 April 2021 (2021-04-22) paragraphs [0012]-[0026], fig. 1-5	1-3, 11-13, 15
A		4-10, 14
Y	JP 2003-213397 A (TAIYO SEIKO KK) 30 July 2003 (2003-07-30) paragraphs [0073]-[0075], fig. 1	1-3, 11-13, 15
A		4-10, 14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

27 October 2022

Date of mailing of the international search report

08 November 2022

Name and mailing address of the ISA/JP

**Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
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Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/033104

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2022/045069 A1	03 March 2022	(Family: none)	
JP 2021-62407 A	22 April 2021	(Family: none)	
JP 2003-213397 A	30 July 2003	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4094473 B [0004]